

REMARKS

I. Status of the Application

Claims 1-4, 6-14, and 16 are all the claims in the application. By this Amendment, Applicant amends claims 1 and 11. No new subject matter has been added.

The support can be found in the specification, for example, on page 7, line 32 to page 8, line 1 and on page 14, line 36 to page 17, line 32, which describe that a fourth nitride semiconductor layer is provided on the third nitride semiconductor layer.

The n-type contact layer is described, for example, on page 15, lines 11 to 27; the n-type cladding layer is described, for example, on page 15, line 15 to page 16, line 8; and the light-emitting layer is described, for example, on page 16, lines 9 to 25.

For example, the specification on page 20, lines 24 to 26 describes that Si is used as an impurity in the barrier layer, and the specification on page 20, lines 31 to 33 describes that the emission output tends to increase when the barrier layer is doped with an n-type impurity.

II. Claim Rejections

Claims 1-4, 6-14, and 16 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Shibata (U.S. Patent Application Publication No. 2002/0155682) in view of Chang (U.S. Patent No. 6,504,183).

Claim 1 recites among other elements: “a light-emitting layer which has a multiple quantum well (MQW) structure including a well layer composed of $\text{Ga}_{1-s}\text{In}_s\text{N}$ ($0 < s < 0.1$) and a barrier layer composed of $\text{Al}_c\text{Ga}_{1-c}\text{N}_e$ ($0 \leq c < 0.3$ and $c < b$) doped with Si, and is provided on the n-type cladding layer.”

Shibata was cited as disclosing a Group III nitride semiconductor element, including AlN single crystal layer 1 provided on a sapphire (Al_2O_3) substrate, an island-shaped second nitride semiconductor layer (2-1, 2-2, 2-3 and 2-4) composed of $\text{Al}_{x_1}\text{Ga}_{1-x_1}\text{N}$ (where $x_1 = 0.1$); a third nitride semiconductor layer 3A composed of $\text{Al}_{x_2}\text{Ga}_{1-x_2}\text{N}$; and a fourth nitride semiconductor layer (13-17) including an n-type layer (13 and/or 14), a light-emitting layer (15), and a p-type layer (16 and/or 17).

However, Shibata describes the light-emitting layer which is a single layer made of i-AlGaN. [0058]. The i-AlGaN is neither n-type nor p-type and has insulation property. Therefore, the light-emitting layer disclosed in Shibata is an undoped AlGaN.

Chang describes that, in forming a multiple quantum well (MQW) layer, a mixed gas only including TMGa, TMIn and NH₃ is introduced. Therefore, a dopant is not introduced. (col. 8, lines 42 to 48). Accordingly, the barrier layer disclosed in Chang is undoped.

Accordingly, neither Shibata, nor Chang teaches or suggests at least “a light-emitting layer which has a multiple quantum well (MQW) structure including a well layer composed of Ga_{1-s}In_sN (0 < s < 0.1) and a barrier layer composed of Al_cGa_{1-c}N_c (0 ≤ c < 0.3 and c < b) doped with Si, and is provided on the n-type cladding layer.”

Additionally, Shibata does not disclose an upper limit for the Al content 0.05 as claimed in claim 1. In the working examples of Shibata, the Al content of the second nitride is x1=0.1 which is twice the upper limit of 0.05 as set forth in claim 1. Although Shibata discloses that the Al content of the second nitride is set smaller than the Al of the first nitride to reduce dislocation density, in no way does this disclose an upper limit for the Al content 0.05 as claimed in claim 1.

The Examiner asserts that as evidenced in Shibata, it is commonly recognized in the art that the parameters such as Al composition ratios of the individually grown layers are result-oriented important parameters, which are commonly subject to routine experimentation and optimization.

However, the Examiner does not cite to any portion of Shibata as suggesting that the Al composition ratio of the second nitride is an art-recognized result-effective variable. Shibata only discloses the Al composition of the second nitride of 0.1, and does not provide any evidence supporting the reduction of the dislocation density when the Al content of the second nitride is further reduced.

Additionally, the Examiner has given no reason why one of ordinary skill would have reduced the Al content of the second nitride of Shibata to an amount of one-half or less than that instructed by Shibata with any reasonable expectation of reducing the dislocation density. Accordingly, because the Examiner did not demonstrate that one of skill in the art would have had any reasonable expectation of success in reducing the Al composition of the second nitride while also reducing the dislocation density, a *prima facie* case of obviousness has not been

established.

If the Examiner maintains this ground of rejection, the Examiner is respectfully requested to provide substantiated support in the prior art and demonstrate why one of ordinary skill would have reduced the Al content of the second nitride of Shibata to an amount of one-half or less than that instructed by Shibata with any reasonable expectation of reducing the dislocation density.

Further, claim 1 recites the third nitride semiconductor layer having the Al content $x2 \leq 0.5$. The Examiner again asserts that the Al content of this layer is recognized as a result-effective variable subject to routine optimization.

However, the claimed upper limit of ≤ 0.5 is substantially less than the Al content of 0.95 as employed in the working examples of Shibata. The Examiner points to no guidance in Shibata for setting the Al content of the epitaxial grown nitride film 3A, but maintains his position that Chang shows that it would have been obvious to set the Al content $x2 \leq 0.5$. This is because Chang is said to teach a top buffer layer with the Al content in the range of $0 \leq x \leq 1$ (col. 3, lines 11-14) and therefore discloses the recited range of between 0.07 and 0.5. (*See* Office Action, page 9, paragraph 3).

The Examiner states that it would have been obvious to make the nitride film 3A of Shibata with a composition ratio between 0.05 and 0.5, to produce a semiconductor device with further optimized performance and/or with further reduced dislocation density. (*See* Office Action, page 5, paragraph 2).

However, Shibata unambiguously states that if a semiconductor light emitting element is constructed of $Al_{0.95}Ga_{0.05}N$ film, the luminance efficiency can be enhanced. And, if a high velocity IC chip was made of $Al_{0.95}Ga_{0.05}N$ film, the response performance can be enhanced. (Paragraph 0074).

The Examiner has given no reason why one of ordinary skill would have reduced the Al content of the third nitride of Shibata to an amount of about one-half and less than that instructed by Shibata with any reasonable expectation of achieving the luminance efficiency, speed of response and/or further reduction in the dislocation density.

Accordingly, because the Examiner did not demonstrate that one of skill in the art would have had any reasonable expectation of success in reducing the Al composition of the third layer

while also achieving the luminance efficiency, speed of response and/or further reducing the dislocation density, a *prima facie* case of obviousness has not been established.

Accordingly, Applicants respectfully submit that the Examiner's proposed combination does not teach or suggest at least "a second nitride semiconductor layer composed of $Al_{x_1}Ga_{1-x_1}N$ ($0 < x_1 \leq 0.05$) ...; a third nitride semiconductor layer composed of $Al_{x_2}Ga_{1-x_2}N$ ($x_1 + 0.02 \leq x_2 \leq 0.5$) ...; and a light-emitting layer which has a multiple quantum well (MQW) structure including a well layer composed of $Ga_{1-s}In_sN$ ($0 < s < 0.1$) and a barrier layer composed of $Al_cGa_{1-c}N_c$ ($0 \leq c < 0.3$ and $c < b$) doped with Si." Also, there is no reason or motivation for one skilled in the art to modify Shibata with Chang to arrive at the subject matter of claim 1.

It is, therefore, respectfully submitted that claim 1 and dependent claims 2-4, 6-14, and 16 are patentable.

CONCLUSION

Withdrawal of all rejections and allowance of claims 1-4, 6-14, and 16 are earnestly solicited.

In the event that the Examiner believes that it may be helpful to advance the prosecution of this application, the Examiner is invited to contact the undersigned at the local Washington, D.C. telephone number indicated below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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